Article type : Consensus Conference

TITLE: Changing Systems Through Effective Teams: A Role for Simulation

Elizabeth D. Rosenman, MD
Division of Emergency Medicine
University of Washington

Rosemarie Fernandez, MD
Division of Emergency Medicine
University of Washington

Ambrose H. Wong, MD, MSEd
Department of Emergency Medicine
Yale School of Medicine

Michael Cassara, DO, MSEd
Department of Emergency Medicine
Hofstra Northwell School of Medicine

Dylan D. Cooper, MD
Department of Emergency Medicine
Indiana University School of Medicine

Maybelle Kou, MD
Department of Emergency Medicine
Inova Fairfax Medical Campus
The George Washington University School of Medicine
Virginia Commonwealth University School of Medicine

Torrey A. Laack, MD
Department of Emergency Medicine
Mayo Clinic

Ivette Motola, MD, MPH
Division of Emergency Medicine
University of Miami Miller School of Medicine

Jessica R. Parsons, MD
Department of Emergency Medicine
Drexel College of Medicine

Benjamin R. Levine, MS
Department of Psychology
University of Maryland

James A. Grand, PhD
Department of Psychology

Rosenman, E. D., Fernandez, R., Wong, A. H., Cassara, M., Cooper, D. D., Kou, M., Laack, T. A., Motola, I., Parsons, J. R., Levine, B. R. and Grand, J. A. (2017), Changing Systems Through Effective Teams: A Role for Simulation. Acad Emerg Med. Accepted Author Manuscript. http://dx.doi.org/10.1111/acem.13260

University of Maryland

Running Title: Using simulation to improve team effectiveness

Corresponding Author:
Elizabeth Rosenman, MD
325 Ninth St.
Box 359702
Seattle, WA 98104
206-744-8337
er24@uw.edu

Key Words:
Team effectiveness, team performance, teamwork, simulation.

Prior Presentation:
The *Academic Emergency Medicine* Consensus Conference: "Catalyzing System Change Through Healthcare Simulation: Systems, Competency, and Outcomes." May 16th, 2017. Orlando, FL, USA.

Funding Sources/Disclosures:
RF and EDR are funded by the Agency for Healthcare Research and Quality (1R18HS020295 and 1R18HS022458-01A1) and the Society for Academic Emergency Medicine Foundation. RF, EDR, and JAG are funded by the Department of Defense US Army Medical Research and Materiel Command (W81XWH-15-1-0403). JAG is funded by the U.S. Army Research Institute for the Behavioral and Social Sciences. The funding organizations had no role in the design and conduct of the study; the collection, analysis, and interpretation of the data; the preparation, review, or approval of the manuscript; or the decision to submit the manuscript for publication.

Potential Conflict of Interest:

[**EDR**]'s institution has received grant money from the Agency for Healthcare Research and Quality and the Department of Defense to conduct research conceived and written by [RF] and from the Society for Academic Emergency Medicine Foundation to conduct research conceived and written by [EDR]. [EDR] reports personal payment from Physio-Control, Inc. for speaker fees.

[**RF]**'s institution has received grant money from the Agency for Healthcare Research and Quality, the Department of Defense, and Physio-Control, Inc. to conduct research conceived and written by [RF] and from the Society for Academic Emergency Medicine Foundation to conduct research conceived and written by [EDR]. [RF] reports personal payment from Physio-Control, Inc. for speaker fees.

[**AHW**] reports no conflict of interest.

[**MC**] reports no conflict of interest.

[**DDC**] reports no conflict of interest.

[**MK**] reports no conflict of interest.

[**TAL**] reports no conflict of interest.

[**IM]** reports no conflict of interest.

[**JRP**] reports no conflict of interest.

[**BRL**] reports no conflict of interest.

[**JAG**]'s institution has received grant money from the Department of Defense to conduct research conceived and written by [RF and JAG] and from the U.S. Army Research Institute for the Behavioral and Social Sciences for research conceived and written by [JAG].

Acknowledgements:
None

ABSTRACT

Teams are the building blocks of the healthcare system, with growing evidence linking the quality of health care to team effectiveness, and team effectiveness to team training. Simulation has been identified as an effective modality for team training and assessment. Despite this, there are gaps in methodology, measurement, and implementation that prevent maximizing the impact of simulation modalities on team performance. As part of the 2017 *Academic Emergency Medicine* Consensus Conference "Catalyzing System Change through Health Care Simulation: Systems, Competency, and Outcomes," we explored the impact of simulation on various aspects of team effectiveness. The consensus process included an extensive literature review, group discussions, and the conference "work-shop" involving emergency medicine physicians, medical educators, and team science experts. The objectives of this work are to: (1) explore the antecedents and processes that support team effectiveness, (2) summarize the current role of simulation in developing and understanding team effectiveness, and (3) identify research targets to further improve team-based training and assessment, with the ultimate goal of improving health care systems.

BACKGROUND

Contemporary patient care has been described as a "team sport" with a reliance on multiple teams to manage an increasingly complex process.[1] Deficits in team performance contribute to errors and near-misses.[2,3] The Emergency Department (ED) in particular is at risk for adverse events[4] due in part to the presence of highly dynamic, complex medical and systems issues. To combat some of these challenges, policy makers recommend that healthcare organizations include team training as part of a comprehensive patient safety program.[5] Consequently, emergency medicine (EM) educators, researchers, and practitioners have invested significant time and resources into implementing and evaluating a variety of team training techniques and methodologies. In large part, these efforts have proven successful for improving learner-level outcomes. For example, simulation-based team training has demonstrated improvement in learner reactions/attitudes, knowledge, and behaviors.[3,6-8]

Evidence for the efficacy of team training on higher-level outcomes measures (e.g., system-level processes, patient safety) is more limited and sporadic.[3,8,9] A significant challenge to establishing this relationship is that the determinants of system-level outcomes are multiple, complex, and at times unknown. Variability in team training practices and assessment methods also limits our ability to definitively link simulation efforts with healthcare outcomes.[3] Although specific components of team training have been recommended,[1], team training is not a homogenous entity. There is substantial variability in quality, content, and format across trainings, as well as in the metrics used to evaluate the impact of training.[10]

We propose that variability in training practices is in part due to gaps in knowledge regarding the relationship between team training and team effectiveness. The objective of this work is to expand the content domain of team effectiveness and identify potential constructs from the team science literature that would be appropriate targets for simulation-based training and assessment. We also discuss a translational science approach to simulation-based team training that will facilitate a better understanding of the links between team training, team effectiveness, patient care, and system-level outcomes. The overarching goal is to identify future directions for leveraging simulation to improve health care systems via effective EM teams.

DEFINING THE TEAM

Emergency medicine teams are considered action teams, defined as a team of experts that function under dynamic, uncertain, and time-pressured conditions (Table 1).[11] In addition, EM teams are ad hoc, with variability in team composition and variability in team member familiarity. Team composition changes from shift to shift, and even from patient to patient. While ED staff may develop general familiarity with their colleagues over time, there is always some variability due to staffing changes, consultants, and medical trainees. This team typology is important to remember when designing training. Simulation-based team training in EM should focus on developing skills pertinent to ad hoc and unfamiliar teams.

Position: Simulation-based team training in EM must be geared towards training *individuals* to perform effectively in any *team*, rather than attempting to train intact teams to perform more effectively.

TABLE 1 HERE

THE ABCs OF TEAM EFFECTIVENESS

Team effectiveness encompasses a broad domain of topics which, outside of healthcare, have been organized into the "ABCs" of affect, behavior, and cognition (Table 1).[17] Team *affect* reflects processes and outcomes related to the interpersonal relations, motivational tendencies, values, beliefs, and perceptions among team members, such as team cohesion, psychological safety, and team efficacy. Team *behavior* includes commonly recognized teamwork processes related to evaluation and planning, monitoring and coordination, and communication.[30] Team *cognition* represents the processes, structures, and capabilities that enable team members to acquire, crystallize, distribute, store, and retrieve knowledge critical for effective team performance. It includes situational awareness, team mental models and transactive memory.[62] All three components must be considered when trying to optimize team effectiveness.[63] Team *behaviors*, or teamwork, have received the most attention in healthcare team training with a strong foundation of supporting research,[10,16,64,65] and thus were not the focus of the consensus process. Instead, this section will explore the less commonly addressed

concepts of team *affect* and team *cognition*. Despite the prevalence of some of these terms, very little research has been done in healthcare, and specifically within EM, related to training or assessing these components of team effectiveness.

Position: Simulation-based team training should expand the focus of learning and assessment beyond teamwork behaviors to include other contributors to team effectiveness.

Team Affect

The components of team affect most relevant to EM teams are likely those that support the rapid development of team-level socialization and facilitate swift coherence of team members.[66] A full discussion of team affect is beyond the scope of this manuscript. We focus on the two components of team affect that were vetted through the consensus process and noted to be critical for ad hoc team effectiveness; team *psychological safety* and *team efficacy*. *Team psychological safety* is defined as the shared belief that the team is safe for interpersonal risk taking.[67] Teams that feel safe are more likely to engage in behaviors that may improve the overall functioning of a team such as requesting help when needed, communicating information, and seeking feedback. Across domains and team typology, proposed antecedents for the development of psychological safety include: leader behavior, mutual trust, and supportive organizational culture.[21,67] *Team efficacy*, which is distinct from self-efficacy, is a shared belief about the group's collective capability. Conceptual models suggest that team efficacy is related to team performance and is more important when interdependence of team tasks is high;[27] a frequent condition encountered by EM teams.

Through the consensus process we discussed simulation-based mechanisms that may be leveraged to develop both psychological safety and team efficacy. Psychological safety can be promoted by carefully structured briefings[68] and debriefings.[69] Success in performing basic and/or simulated tasks, and observation of both successful and unsuccessful teams can help build team efficacy.[70,71] However, a significant challenge for targeting affective outcomes in EM teams is the variability in team composition that precludes identifying and training teams that consistently work together over time. Further research is needed to determine whether shifts in individual affect realized through simulation transfer to clinical teams irrespective of the

team membership.

Understanding the role of individuals in shaping team affect in dynamic or ad hoc teams is critical for EM teams. As noted above, team leaders can positively impact the development and maintenance of effective team affect. Team leaders influence the development of psychological safety through coaching behaviors.[20] Specifically, team leader behaviors, including coaching, positively influences team member comfort with "speaking up" in operating room teams.[72] Within neonatal intensive care units, leader inclusiveness, described as words and actions that encourage and value input from others, was associated with improved psychological safety.[73] Team leaders can frame successes and failures in ways that develop team efficacy and reinforce a mastery learning orientation.[74] Taken together, this work highlights potential training targets for individuals (i.e., team leaders) that can foster development of psychological safety and team efficacy independent of team composition. While there is increasing appreciation for the importance of team affect within healthcare, more work is needed to understand how to effectively target team affective outcomes in EM teams.

Position: Simulation-based research efforts should explore how team affect constructs, including psychological safety and team efficacy, are developed and supported. Subsequent efforts should investigate the impact of training individuals to promote and maintain desirable affective outcomes in ad hoc and unfamiliar teams.

Simulation-based team training has been shown to effect changes at the unit and system levels by changing institutional culture.[75] The concept of *safety culture* is distinct from team affect, yet is likely developed through similar mechanisms and may moderate the impact of team training on team performance and transfer of skills to the clinical environment. Safety culture is defined as "the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management."[22] Evidence suggests that organizations with stronger safety cultures tend to have fewer adverse events, more frequent reporting of near misses or errors, and better communication among team members.[76,77] Thus,

simulation-based team training may be able to indirectly target team affective outcomes in ad hoc teams by contributing to a strong culture of safety. Further work is needed to determine whether shifts in attitude realized through simulation transfer to team level affective outcomes in the patient care setting.

Position: Research efforts should explore the relationship between unit and system level metrics (e.g., safety culture) and team affect constructs within ad hoc and unfamiliar teams during patient care delivery.

Evaluating the effectiveness of simulation-based training on team affective outcomes, either through individual-level behaviors or system-level culture change, requires accurate and reliable assessment methodologies. To date, efforts have largely been limited to perception-based measures. Several versions of a questionnaire specifically targeting psychological safety,[67] and a questionnaire targeting the related concept of team climate,[78] have been applied in the team science literature. Within healthcare, there are several questionnaires related to safety culture and teamwork that include questions related to components of team affect, including psychological safety and team efficacy. Examples include the Hospital Survey On Patient Safety,[79] the TeamSTEPPs® Teamwork Perceptions Questionnaire,[80] the TeamSTEPPs® Teamwork Attitudes Questionnaire,[81] the Safety Attitudes Questionnaire, [82] and the Safety Climate Survey.[83] Both the TeamSTEPPs® Teamwork Attitudes Questionnaire and the Hospital Survey On Patient Safety have been used in EM to assess the impact of simulation-based team training on learner attitudes towards teamwork and perceptions of safety culture.[84]

Although research using existing tools has provided an entry point to the study of healthcare team affect, there are several limitations and knowledge gaps that must be addressed. First, most "team" affect measures capture individual data and are then aggregated to the team level. While this may be appropriate for a given assessment, it is important to specify level of analysis when designing, implementing, analyzing, and interpreting data from team-level measures.[85] Additionally, most studies rely on self-report and do not attempt to correlate or triangulate findings with more objective measures, such as an observable change in behavior. These limitations are not exclusive to research in healthcare teams, but rather

represent challenge to team affect measurement across domains. The development of objective measures of team affect will require novel measurement technologies (e.g., learner physiologic data, communication analysis) that are still in the early stages of development and implementation.

To improve assessment practices, we recommend exploring team-level processes that might be influenced by team affect. For example, the presence of psychological safety within a team could be expected to influence communication patterns as the result of increased comfort with "speaking up." Rather than, or in addition to, surveying team members' self-reported psychological safety, resuscitations could be analyzed for frequency and direction of communication. Further work is needed to identify, develop, and evaluate team affect measures relevant to EM teams.

Position: Research should focus on identifying appropriate assessment methodologies for measuring the impact of simulation-based training on team affect in EM teams.

Team Cognition

A team's ability to efficiently acquire, share, and interpret information, and the knowledge of where resources can be found within the team, allows members to anticipate and execute actions as a coherent unit rather than as separate individuals. These processes, and their resultant outcomes, represent team cognition. Team cognition is a critical component of team effectiveness.[62] We focus on three distinct but related conceptualizations of team cognition: *situational awareness*, *team mental models*, and *transactive memory systems*. Each of these facets emerges as team members gather and exchange information from the environment and other individuals while engaged in task-relevant activities.[34,35] The extent to which these processes result in *shared* and *accurate* cognitive representations of the needs, goals, and status of a team and its tasks is indicative of the quality of team cognition.

Research outside of healthcare suggests that the processes and outcomes relevant to team cognition are amenable to change through targeted interventions, such as leader briefing and team-interaction training,[86] cross-training,[87], guided self-correction[88], and the provision of real-time guidance directing teams towards effective information gathering and sharing

strategies.[35] However, as with team affect, application of these techniques is challenging in ad hoc teams with unstable membership. Training designs that facilitate the development and maintenance of team cognition through prolonged shared experiences are not feasible.[89] Team training must instead identify and focus learning towards generalizable protocols, communication strategies, and roles that facilitate desirable team cognitive outcomes.[39] For example, several large scale team training programs; including TeamSTEPPs®[90] and CRM (crisis resource management), which has been modified for anesthesia[91] and EM,[92,93] promote the use of simulation-based training as a platform for teaching fundamentals of team communication, monitoring, and information gathering, all behaviors that support the development of team mental models and situation awareness. By promoting a shared lexicon, these programs may facilitate communication across teams and situations.

Not all information sharing is created equal,[62] and a high volume of team communication does not necessarily mean a high quality team cognition is present or emerging.[94,95] EM teams must move beyond generic team training skills presented in TeamSTEPPS to be able to rapidly and effectively develop shared team cognition under time-sensitive, dynamic conditions. For EM teams, it is critical that team members identify *who* needs to know *what,* as well as how to decide *when* to communicate this information. Simulation is an ideal platform for practicing skills conducive to team cognition development, but more further research is needed to (a) identify the specific behaviors related to information acquisition and sharing that are pertinent to EM teams, (b) determine training techniques and content that optimize team cognition development, and (c) develop measurement tools to support the provision of feedback related to team cognition.

Position: Simulation-based research efforts should focus on identifying and training generalizable communication strategies that promote team cognition processes in ad hoc and unfamiliar teams.

Parallel efforts are needed to advance the development and implementation of team cognition assessments in healthcare training and research. There are a numerous approaches and considerations for assessing team cognition.[96-99] Measurement techniques outside of

healthcare have included observation of behavioral indicators/markers;[34,100] evaluation of agreement in direct/self-report measures;[96,101] and the analysis of unobtrusive measures such as communication transcripts or sociometric sensors.[95,102] In contrast, team cognition has seldom been a focus of measurement in healthcare.[39,103] Attempts have been made to assess situational awareness in simulated scenarios involving medical students[104] and trauma teams.[105] Burtscher et al report one of the most robust evaluations of team mental models during simulated anesthesia inductions.[106] However, rigorous measurement of team mental models and transactive memory systems during complex team-based tasks remain elusive.

Behavioral observation and self-reporting methods are most familiar to healthcare researchers and can serve as an entry point for incorporating measures of team cognition into existing research and training protocols. However, it is important to remember the limitations associated with such metrics. Coding behavioral makers requires a significant investment of time and resources. Behavioral observations and self-reporting can be disruptive if administered during task activity, but may have inaccuracies if collected retrospectively. Educators and researchers should also consider and evaluate the capabilities of emerging techniques for measuring team cognition (e.g., automated text processing, wearable technologies). Simulation-based environments will be particularly amenable to investigating these various team cognition assessment approaches. As with team-level affect measures, it is critical to consider level of analysis issues when aggregating individual data to the team level.[85] **Position: Research should explore and evaluate the utility and feasibility of multiple methods for assessing the impact of simulation-based training on team cognition in EM teams.**

ADVANCED TEAM PROCESSES

Team affect, behavior, and cognition support team effectiveness and are the building blocks for more complex phenomena that are critical to EM teams. As noted above, teams within EM are often variable in composition and complex in structure. Furthermore, these teams must function under dynamic and unpredictable conditions. This requires advanced team processes, including team adaptation, leadership, and the ability to function within a multiteam system (MTS). Team adaptation involves routine teamwork behaviors, such as monitoring and

planning, applied in an iterative process. Effective team leadership is contingent on the situation and the team, but it ultimately falls on the leader to support team performance, which may include promoting a positive team affect, the development of team cognition, and appropriate team processes. Finally, leadership and communication structures are thought to be key determinants of the ability of individual teams to interact effectively within the larger healthcare system.

Position: Building on a more comprehensive view of team effectiveness, subsequent efforts should focus on understanding and improving training interventions relevant to advanced team phenomena, including team adaptation, leadership, and the ability to function within a multiteam system.

Team Adaptation

Team adaptability reflects the capacity for a team to change how it operates in response to disruptive forces from the environment in order to recover or improve team effectiveness.[48,107,108] More recently, researchers have demonstrated the importance of distinguishing between team adaptability as a static characteristic stemming from the attributes of team members and *team adaptation*—the dynamic affective, behavioral, and cognitive processes through which adaptive change occurs, such as information sharing, goal and strategy prioritization, and performance monitoring.[49,109] Both team adaptability and team adaptation are central to effective performance in contexts where situations can be unpredictable; information is incomplete, ambiguous, or changes rapidly; and group membership is fluid.[110]

Methods for developing adaptive expertise within teams represent an important training need in many modern organizations,[111] including healthcare and EM.[4,112] Examination of training interventions for adaptation at the team-level have been relatively limited, though models designed to target performance adaptation at the individual-level provides insight into potentially useful training targets.[113] For example, intentionally scaffolding training such that the focus of learning progresses from procedural “how to” knowledge, to strategic “why/when” knowledge, and finally to generalization “what now/what next” knowledge is critical to

developing foundational adaptive skillsets.[114,115] The provision and nature of feedback systems to improve adaptation have also been identified as critical leverage points. Specifically, research has identified the importance of feedback that directs learners to "project forwards" rather than "reflect backwards," interpret and anticipate errors as inevitable yet manageable, and provide support for the affective and cognitive dissonance that arise when applying knowledge to solve new problems.[116-119]

The degree of control over the environment and feedback mechanisms makes simulation-based training an ideal platform for studying and developing training protocols that target team adaptability and adaptation.[113] Nevertheless, there are a number of areas in which simulation-based training and assessment related to team adaptability within healthcare systems is needed. First, not all environmental disruptions are the same. The needs and demands that emerge when team membership changes (e.g., new members arrive, existing members are pulled away), versus when a patient's condition deteriorates, are different and likely place different affective, behavioral, and cognitive demands on a team. Consequently, greater attention is needed to develop training interventions that systematically identify *to what* must teams adapt in order to facilitate the development of guidance to effectively manage these different circumstances.[109] Second, concerted efforts to assess both the *outcomes* and *processes* of team adaptation before, during, and after simulation-based training will be needed. Team adaptability and adaptation are multifaceted concepts that dynamically affect and are affected by many of the team ABCs previously discussed. As a result, attempts to improve adaptive expertise will benefit most from assessment techniques capable of measuring aspects of team affect, behavior, and cognition before, during, and after team activity. More encompassing assessment strategies will not only enable researchers and trainers to identify potential bottlenecks in a team's adaptive capacities, but also better understand where and how specific training interventions influence team function.

Position: Simulation-based training targeting team adaptation should incorporate measures and feedback specific to both process and outcome.

Position: Simulation-based research in team adaptation should explore the nature and implication of disruptions common in EM to better understand the adaptive needs of EM teams.

Team Leadership

The patient safety literature demonstrates the importance of team leadership skills in reducing errors and improving patient outcomes, especially in acute care settings.[3,120] Additionally, team leadership has become a topic of interest across the spectrum of medical education. The EM residency milestones include sub-competency in Team Management, which includes some team leadership skills.[121,122] Resuscitation guidelines for licensed providers, such as Advanced Cardiac Life Support, include team leadership components.[123] Historically, healthcare providers were expected to function as effective team leaders with minimal training. This gap in training was identified during the 2008 *Academic Emergency Medicine* Consensus Conference on The Science of Simulation in Healthcare.[124] Through that consensus process, team leadership training and assessment were identified as research priorities in EM.

Although team leadership has received more attention over the past decade, training and assessment practices remain inconsistent. To optimize team performance via improved team leadership, the leadership construct itself needs to be better understood. A systematic review of team leadership training in healthcare revealed that leadership training is frequently implemented as a component of broader teamwork training, and training efforts rarely cite a specific team leadership model as the foundation for the educational content.[125] Likewise, the assessment of team leadership competencies continues to be challenging. Most published team leadership assessment tools in healthcare are not systematically developed and tested, resulting in threats to validity.[126,127] As with leadership training, assessment tools include leadership components as part of a broader teamwork assessment, rather than focusing on leadership specifically. Assessment instruments are quite variable in structure, and include checklists, global-rating scales with or without behavioral or frequency anchors, and frequency of leadership utterances as their structure.

This inconsistency in the approach to training and assessing leadership is, in part, due to the lack of a commonly accepted taxonomy of leadership behaviors. One proposed categorization of team leadership behaviors involves dividing behaviors into task-focused leadership, person-focused leadership, and task interdependence.[128] A second approach applies leadership behaviors to an existing taxonomy of teamwork behaviors.[30] This taxonomy contains three main categories: transition processes (e.g., mission analysis, goal specification, strategy formulation, and reflection), action processes (e.g., monitoring progress towards goals, systems monitoring and adaptation, coaching/backup, and coordination), and interpersonal skills (e.g., conflict management and effective communication). These models serve as a starting point for understanding team leadership, but further work is required to ensure a comprehensive and specific taxonomy for EM team leadership behaviors.

Position: A commonly accepted taxonomy of EM team leadership behaviors is needed to guide the development of leadership training and the assessment of leadership skills.

Building on the team leadership theory of dynamic delegation presented by Klein, et al., we argue that team leadership in EM is contingent and functional.[15] Team leadership can influence all aspects of team effectiveness, including team affect, team processes, and team cognition (Figure 1). In a time-pressured situation with an unfamiliar team, for example, a leader may foster psychological safety by explicitly seeking input, optimize team processes by setting clear priorities, and promote situational awareness by "talking aloud." The importance of team leadership, and specific ways in which effective team leadership can improve team performance, have been identified in various sections throughout this manuscript (e.g., team affect, team adaptability, MTS). While we focus on "the" team leader, it is important to note that team leadership is often shared.[15] Any member of the team can exhibit leadership behaviors, and team leadership training does not need to be limited to providers historically identified as the team leader (e.g., physicians). In situations of shared leadership, it is important to remember that leadership should not be shared simultaneously, but rather through an explicit hand-off of leadership between individuals. Focusing on leadership behaviors can overcome some of the challenges of team training in EM, by training individuals to improve all

aspects of team performance regardless of patient factors, task work, and team composition. **Position: Simulation-based team leadership training in EM should focus on developing skills that allow leaders to rapidly develop team affective, behavioral, and cognitive processes in ad hoc teams.**

Multiteam Systems

A multiteam system (MTS) occurs when "two or more teams work directly and interdependently … toward the accomplishment of collective goals."[59] EM teams frequently function as part of a MTS (e.g., a pregnant trauma patient with multiple consulting teams). Research involving team training in healthcare simulation has predominantly focused on within, or intra-, team performance, with limited exploration of MTSs and inter-team collaboration. Interprofessional education (IPE) has become an important topic in team and simulation-based training, but the focus of IPE often includes multiple professions (e.g., RN, MD, RT) as members within the same team, rather than interdisciplinary education involving multiple teams. Outside of health care, studies have shown that inter-team performance is more important than intra-team performance in determining the overall performance of the MTS.[129] Although research on MTSs is still in its infancy, a number of key MTS attributes have been identified that may help guide efforts to develop simulation-based training targets relevant to improving MTSs in healthcare settings.

The *developmental* attribute of a MTS describes how the MTS is created and how it evolves over time. MTSs can be planned in advance or occur emergently to meet a need, and both types of MTSs occur in EM.[2,130] MTS *compositional* attributes include the number and types of teams involved. There are demonstrated benefits to the diversity of expertise with a larger number of teams,[131,132] but increasing the size of a MTS could also have a negative effect on performance due to communication challenges and competition for resources.[2,61] MTS leadership training can help team leaders set and prioritize goals to mitigate these potential challenges.[130] Finally, the *linkage* attribute of a MTS describes the relationship between individual teams, including leadership and communication structures. Specific MTS leadership training resulted in higher levels of inter-unit coordination in military teams.[60] Shared

leadership (i.e., members of the team mutually leading each other towards a common goal) has been shown to improve inter-team performance during simulated in-flight emergencies.[133,134] As with leadership, communication can also be shared through a decentralized communication structure that allows teams to directly communicate with each other. In simulated Air Force exercises, decentralized communication networks were associated with improved MTS performance.[135,136] Shared leadership and decentralized communication may also improve MTS performance within emergency healthcare teams, however more work is needed to explore this concept.

Position: Research efforts should explore processes that impact inter-team performance within multiteam systems. Simulation provides a viable platform to conduct this research.

ASSESSING SIMULATION-BASED TEAM TRAINING

Simulation is a common platform for team-based training.[10] Unfortunately, inconsistency in reporting outcomes and in defining effectiveness has made it difficult to transform simulation-based training efforts into improved health outcomes and care provision.[137-139] The biomedical sciences have encountered similar challenges, and experts have proposed a three-phase roadmap of translational research (the "3T's") to facilitate the transition from basic science to patient care.[140] In this translational science model, the T1 phase moves basic bench discoveries toward clinical studies, the T2 phase then produces evidence of clinical effectiveness for individual patients, and the T3 phase addresses health care delivery and preventative strategies that improve the health of populations and society.[141] Recently, the simulation research community has been tasked with using an analogous translational science model to demonstrate distal results related to improved patient outcomes.[142]

A Translational Science Approach to Simulation-based Team Training

In a simulation-specific translational science model, T1 science demonstrates efficacy through improvements in knowledge, skills and attitudes of providers and teams in the simulation laboratory (Figure 2). At the next stage, T2 science impacts provider and team behaviors in the clinical setting, effectively demonstrating transfer of skills to a clinical setting.

At the final level, T3 science evaluates the effect of an intervention on patient-level outcomes, such as decreased procedural complication rates, improved patient function, or decreased mortality.[143] While simulation research strives to demonstrate that training interventions result in provider competence and improved patient outcomes, T1 level studies are the most common form of published work. More effort is needed to understand and incorporate assessment measures for T2 and T3 level outcomes in order to reach this goal of improving patient care.

There are many challenges to conducting studies involving T2 and T3 level outcomes. One key issue is that measuring and capturing clinical data can be difficult and requires significant resources and funding to successfully demonstrate direct results from an educational intervention.[3] Novel approaches to consolidating clinical and research data into large databases, similar to the "big data" used in other fields (e.g., retail sales, search engines, and astronomy), has great potential to address this barrier.[144] Use of large data sets can facilitate detection of improvements in patient outcomes through simulation-based team training efforts across multiple institutions. Further downstream effects of team training, or so-called "T4" outcomes, may include reduced health care costs,[145] or impact on other trainees.[146]

Position: Research in simulation-based team training should apply a translational science framework with the goal of targeting higher-level outcomes.

Although team training should strive to affect T2 (behaviors in the clinical setting) and T3 (patient outcomes), it is also important to understand the mechanism by which these outcomes occur. Demonstrating T2 and T3 level changes often require large-scale interventions, over long periods of time, and with many confounding variables. Simulation-based assessments provide information on team performance that can identify which variables are important for analysis at T2 and T3 levels, and can help link an intervention, such as team training, to these higher-level outcomes. For example, simulation has been used to discover deficiencies in team performance such as delays in initiation of CPR and poor coordination,[147] and delays in initiation of resuscitation guidelines.[148] In situ simulation has also emerged as a platform to identify latent systems-based safety threats,[149] non-technical skills required for team function,[150] team performance ratings,[151] and response to trauma care or disasters.[152,153]

This application of simulation is critical to identifying elements of team performance that need to be targeted. For training interventions with T2 or T3 level outcomes, a T1 simulation-based assessment can provide insight into why the intervention was, or was not, successful and thus can help inform future curricula development and modifications.

Position: Simulation-based assessments serve an important role in establishing and understanding the relationship between team training and higher-level outcomes.

SUMMARY

Healthcare systems rely on effective teams. Simulation has been promoted as a platform for training and assessing team performance, however the complexity of healthcare teams has challenged these efforts. Overcoming this obstacle requires understanding the nature of EM teams and the many dimension of team effectiveness. This work explores the foundation of team effectiveness, focusing on team affect and team cognition. In addition, we discuss several advanced team processes that build on these fundamentals. Throughout this overview we highlight the role of simulation-based training in targeting these constructs and identify resources from the team science literature that can help inform future training and research efforts in healthcare teams. Continued collaboration between educators and researchers from EM and the team sciences is critical to advancing this work. Finally, we emphasize the importance of using a translational science approach to evaluating simulation-based team training to further elucidate the relationship between training and systems level outcomes.

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FIGURES

Figure 1. Team Leadership Model

Figure 2. Translational Science Model for Simulation-based Team Training

Table 1. Definition of Terms

Term	Definition	Key Citations
Team Typology		
Team	Social units with two or more members working both *independently* (individual task work) and in *collaboration* (interdependent teamwork) within a system (an organization) using a variety of processes to coordinate, integrate, and complete tasks.	• Salas, et al. (1992)[12] • Kozlowski & Bell (2003)[13] • Hackman (1987)[14]
Action teams	Teams of experts functioning under dynamic, uncertain, and time-pressured conditions. May have consistent ("stable") or variable ("ad hoc", "dynamic", or "unstable") composition.	• Sundstrom, et al. (1990)[11] • Klein, et al. (2006)[15] • Fernandez, et al. (2008)[16]
Team Affect		
Team affect	The interpersonal relations, motivational tendencies, values, beliefs, and perceptions among team members, such as psychological safety, team cohesion, and team efficacy.	• Kozlowski & Ilgen (2006)[17] • Park, et al. (2013)[18] • West, et al. (2009)[19]
Psychological safety	Shared belief that is safe to take interpersonal risks.	• Edmondson (1999)[20] • Frazier, et al. (2017)[21] • Nieva & Sorra (2003)[22]
Team cohesion	Individuals' psychological perceptions of attraction to a group (interpersonal cohesion), task commitment (task cohesion), and pride in a group that motivates team to remain together.	• Beal, et al. (2003)[23] • Gully, et al. (1995)[24] • Salas, et al. (2015)[25] • Graetz, et al. (2014)*,[26]
Team efficacy	Team's self-perception of the group's collective skills and ability to succeed.	• Gully, et al. (2002)[27] • Stajkovic, et al. (2009)[28] • Feltz & Lirgg (1998)[29]
Team Behavior		
Team behaviors (processes)	The commonly recognized teamwork processes related to evaluation, planning, monitoring, coordination, and communication.	• Marks, et al. (2001)[30] • LePine, et al. (2008)[31] • Rousseau, et al. (2006)[32] • Fernandez, et al. (2008)*[16]
Team Cognition		
Team cognition	The organized processes, structures, and capabilities that enable and support team members' abilities to acquire, crystallize, distribute, store, and retrieve knowledge critical for effective team performance.	• DeChurch and Mesmer-Magnus (2010)[33] • Salas, et al. (2007)[34] • Grand, et al. (2016)[35] • Fernandez, et al. (2017)*
Team mental models	Team members' shared understanding and mental representation of knowledge (content and organization) relevant to key elements of the team's task environment.	• Cannon-Bowers & Salas (2001)[36] • Klimoski & Mohammed (1994)[37] • Rouse, et al. (1992)[38] • Fernandez, et al. (2017)*,[39] • Burtscher, et al. (2011)*,[40]
Transactive memory systems	Distribution of knowledge storage and information processing functions across team members coupled with a collective awareness of "who knows what." Three critical dimensions: knowledge specialization, credibility, and coordinated information retrieval.	• DeChurch & Mesmer-Magnus (2010)[33] • Moreland (1999)[41] • Wegner (1987)[42] • Fernandez et al. (2017)*,[39]

Term	Definition	Key Citations
Situational awareness	Collective efforts to perceive key elements in the environment, understand their meaning, and project their status in the future.	• Endsley (1995)[43] • Salmon et al (2008)[44] • Gardner, et al. (2017)*,[45] • Wright, et al.*,[46] • Lowe, et al.*,[47]
Team Adaptation		
Team adaptability	The ability of a team to response to disruptions and evolving demands in the work environment (outcome).	• Randall, et al. (2011)[48] • Maynard, et al. (2015)[49] • Bell & kozlowski (2002)[50]
Team adaptation	The processes that facilitate strategic cognitive, affective, motivational, and behavioral modifications and adjustments to improve team function (process).	• Baard, et al. (2014)[51] • Burke, et al. (2006)[52] • Lepine (2005)[53]
Team Leadership		
Action team leadership	The behaviors necessary to support the development and function of action teams. Behaviors are contingent on task and team (experience, expertise, familiarity) characteristics. Thus, leadership is a dynamic process necessitating adaptation to changes in the team and task.	• Kozlowski, et al. (1996)[54] • Morgeson, et al. (2010)[55] • Yun, et al. (2005)*,[56] • Klein, et al. (2006)*,[15] • Rosenman, et al (2014)*,[57] • Rosenman, et al (2015)*,[58]
Multiteam Systems		
Multiteam system (MTS)	Two or more teams working directly and interdependently toward the accomplishment of collective goals.	• Mathieu, et al. (2001)[59] • DeChurch & Marks (2006)[60] • DiazGranados, et al. (2014)*,[61]

*Healthcare focused publication

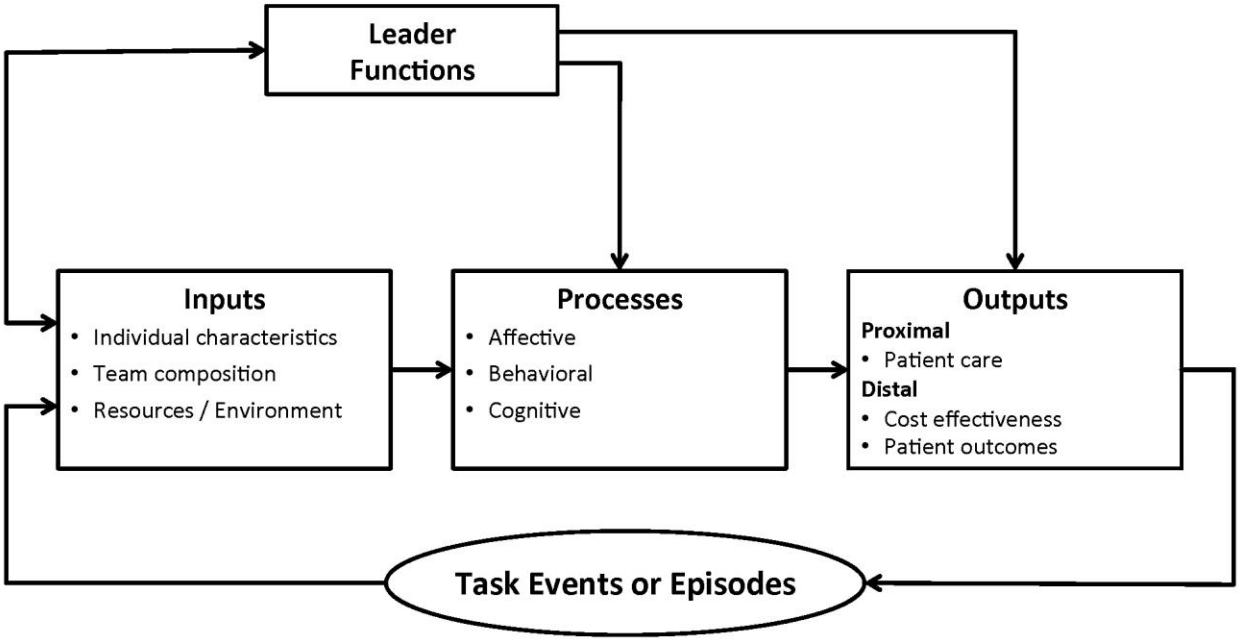

Figure 1. Team Leadership Model. Adapted from work by (1) Kozlowski, et al. A dynamic theory of leadership and team effectiveness: Developmental and task contingent leader roles. In: Ferris GR, ed. *Research in personnel and human resource management*. Greenwich, CT: JAI Press; 1996:253-305 and (2) McGrath J. *Groups: Interaction and Performance*. Englewood Cliffs, New Jersey: Prentice-Hall; 1984.

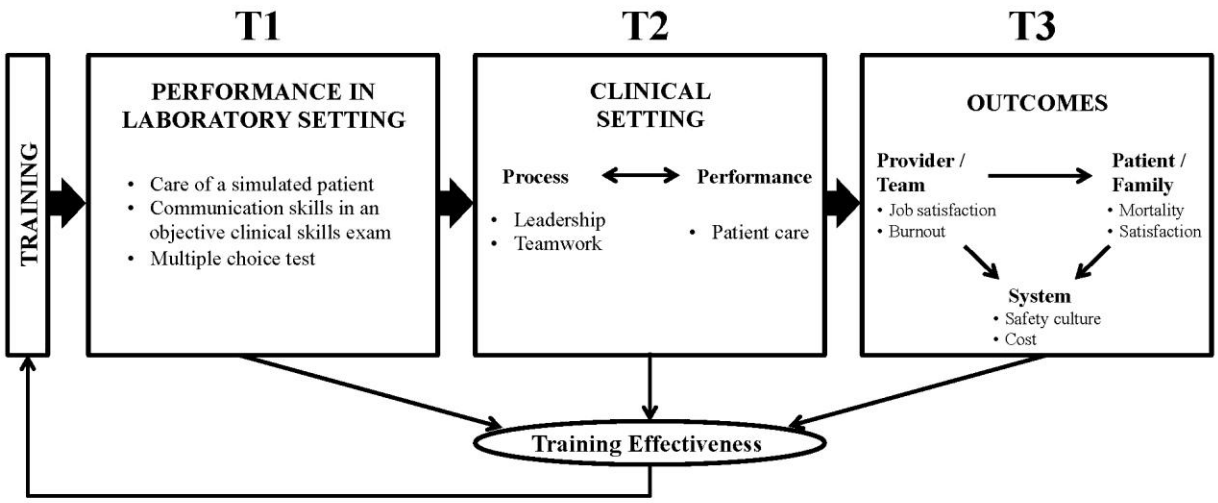

Figure 2. Translation Science Model for Simulation-based Team Training